NASA Facts

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SPACE RADIATION SHIELDING PROGRAM

A human crew voyages through space -- far from Earth's shielding atmosphere and magnetic field. A satellite sends a warning forecast: energetic particles are being accelerated from the Sun's corona, sending dangerous radiation toward their spacecraft. The crew isn't worried. Long before their journey, researchers on Earth conducted experiments to accurately measure the hazards of space radiation and developed new materials and countermeasures to protect space explorers.

Overview

The Space Radiation Shielding Program is part of the Space Radiation Initiative – a new initiative sponsored by NASA's Office of Biological and Physical Research (OBPR) at NASA Headquarters. The goal of the program is to keep astronauts fit and healthy as they travel through the solar system and after they return.

Historically, two factors have kept the radiation exposure of astronauts safely below the levels recommended by the National Council for Radiation Protection: The walls of spacecraft serve to partially shield astronauts from radiation; and, in the past two decades, U.S. astronauts have been in space for relatively short periods. But with the advent of longer missions on the

International Space Station, crew deployments must be limited to protect them from to much radiation exposure. With the prospects of humans traveling through deep space to the Moon or Mars in the future, astronauts will be exposed to radiation for longer periods -- exposures that could be hazardous to their health and put them at risk for cancer and other radiation-induced illnesses.

Astronauts living and working on the International Space Station are exposed to radiation from several sources: radiation trapped in Earth's magnetic field, galactic cosmic radiation from supernova explosions and other sources and bursts of radiation from the Sun.

Space radiation is more dangerous, and hundreds of times more intense than natural radiation sources on Earth. A Shuttle mission to the International Space Station that doesn't include a space walk outside where radiation exposure is even greater, exposes the crew to the equivalent of 20 chest X-rays. A typical six-month stay on the Space Station exposes the crew to the equivalent of 1,000 chest X-rays at solar maximum--the period when the Sun is most active and ejects more energetic particles --and to 300 chest X-rays during solar minimum -- the period when the Sun is least active and ejects fewer energetic particles.

When astronauts one day travel even farther than the Space Station, which orbits 240 miles above Earth, they will leave behind the protection of Earth's shadow and it's magnetic fields. They will encounter the full intensity of galactic cosmic rays, particles that are bare atomic nuclei stripped of all electrons. These particles have both high energies and high electrical charges (HZE particles). Crews will also encounter secondary protons and neutrons created as the cosmic rays interact with spacecraft and their own bodies. When intensely ionizing particles strike human tissue, they can damage cells and sometimes alters genetic material in a way that eventually leads to cancer.

Scientists need to increase their understanding of the biological effects of the radiation environment, both in low-Earth orbit – a few hundred miles above Earth where the Space Shuttle and Space Station travel – and beyond. The results of research conducted under the new Space Radiation Initiative will enable NASA to ensure astronauts can staff the Space Station for three 180-day missions and eventually journey on a 1,000-day mission beyond low-Earth orbit – without going over radiation exposure limits recommended by the National Council for Radiation Protection.

The research is a new interdisciplinary effort, with investigations being conducted jointly by biologists and physicists. They will quantify the risks for humans and find shielding materials and countermeasures that will protect them. NASA's Marshall Space Flight Center in Huntsville, Ala., leads the research team studying radiation shielding for NASA's Physical Sciences Research Program.

The research on radiation shielding has two objectives: to accurately determine the radiation shielding effectiveness of materials used in spacecraft inhabited by humans and to develop new materials that are more effective radiation shields.

Determining the Effectiveness or Radiation Shielding

To determine the effectiveness of radiation shielding, scientists are obtaining data on how radiation interacts with the shielding materials and using the data in computer models that calculate the effectiveness of particular shielding arrangements. NASA is funding two consortia to accomplish this task.

The first team of scientists is measuring how radiation is altered and attenuated by the various materials used in spacecraft. The second is using existing and newly measured data on radiation transport -- including data collected on the Space Station -- and the measurements made by the first group. They will take all the data and develop radiation transport computer codes -- computer models and simulations that will allow scientists and spacecraft designers to assess the shielding effectiveness of particular spacecraft.

Designing New Radiation Shields

Up to the present, spacecraft inhabited by humans have primarily been constructed of aluminum. But measurements made in spacecraft and at accelerators have shown that aluminum is not a very effective shielding material. If astronauts are to travel further away from Earth where radiation levels are higher and if they are to stay in space longer, spacecraft designers must build vehicles with materials that provide better shielding.

Assessments of the radiation shielding effectiveness of various materials with presently available computational tools show that shields -- even made from the most effective materials -- must be massive. Massive shields are undesirable because spacecraft need to be lightweight. NASA is funding scientists to develop new materials that make more effective shields than aluminum and can be used to construct future human spacecraft.

Raj Kaul, a materials scientist at NASA's Marshall Space Flight Center, examines a brick of space radiation shielding material.

Simulating Space Radiation on the Ground

Since the 1970s, NASA has been using Earth-based facilities to simulate the space radiation environment and understand and mitigate the biological risks of space radiation.

NASA biologists and physicists are continuing their studies in accelerators around the world. Now with the opening of the new $34 million NASA Space Radiation Laboratory, they will be able to perform thousands of measurements -- tripling their experiment time. The laboratory was commissioned on Oct. 14, 2003, at the Department of Energy's (DOE) Brookhaven National Laboratory in Upton, N.Y. This unique national resource, built in cooperation by NASA and DOE, is one of the few places in the world that can simulate the harsh space radiation environment.

Experiments using the NASA Space Radiation Laboratory will help NASA biologists and physicists understand and quantify the risks for humans and find shielding materials and countermeasures that will protect them. Approximately 80 investigators will conduct research each year using the new facility.

For each experiment, the accelerator produces beams of heavy ions – particles making up the atomic nuclei of iron, silicon, carbon or titanium and other atoms. These ions are typical of those accelerated in cosmic sources and by the Sun. The beams of ions move through a 100-meter transport tunnel to the 400-square-foot, shielded target hall. Here, they hit the target, which may be a biological sample or shielding material.

The National Space Radiation Laboratory will allow scientists to simulate the harsh space radiation environment.

Since the accelerator produces controlled beams of known particles at specific energies, physicists can measure how specific particles interact with shielding material. This information can be used to predict the effectiveness of various materials and to develop and test new materials.

The radiation shielding team will place sections of potential shielding materials in the path of the beam and measure how effective the material is at blocking different types of particles. They will use thin targets made of one atomic element to measure how that element breaks up particles in the beam. Physicists will use this experimental data to refine models for shielding effectiveness.

The NASA Space Radiation Laboratory is designed to take advantage of the high-energy particle accelerators located at Brookhaven National Laboratory, a DOE facility established in 1947. If the NASA Space Radiation Laboratory were constructed as a stand-alone facility, construction and operation costs would be at least three times more expensive.

In addition to the particle accelerators, tunnel and related equipment, the facility contains five laboratories and other support facilities. Construction of the new facility began in 1998, and was funded in part by NASA's Office of Biological and Physical Research.

Performing Experiments in Space

In addition to studies performed on the International Space Station, scientists will test the new shielding effectiveness codes and the new shielding materials in the deep space environment.

Scientists at NASA's Marshall Space Flight Center are developing a balloon-borne test facility that can carry shielding material high above Earth's protective atmosphere where the radiation hazards are similar to those experienced in deep space. The shielding material will be outfitted with sensors that can monitor how radiation penetrates and interacts with the shielding material.

Balloons can be used to carry radiation shielding monitors and materials high above Earth's protective atmospheric cushion.

The Space Radiation Shielding Team

In the past year, NASA has used a peer-review process to select and award grants to fund the investigations of science teams managed by the Space Radiation Shielding Program. For a complete listing of the radiation shielding team, please visit:

http://www.radiationshielding.nasa.gov/people.html

NASA Research Announcements are continuing to evaluate and select new team members to conduct these studies. More information on upcoming solicitations can be found at:

http://research.hq.nasa.gov/code_u/code_u.cfm

For more information on the Internet, please visit:

http://www.nasa.gov
http://www.bnl.gov

Radiation Shielding
http://www.radiationshielding.nasa.gov

Space Radiation Health Project
http://srhp.jsc.nasa.gov/index.cfm

Office of Biological and Physical Research
http://spaceresearch.nasa.gov/

International Space Station Science Operations
www.scipoc.msfc.nasa.gov

Human Space Flight
www.spaceflight.nasa.gov

Microgravity Science
http://www.microgravity.nasa.gov